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Contamination of Cereals (*Sorghum Bicolor L. Moench* and *Pennisetum Glaucum (L.) R. Br.*) During Storage: Farmer's Perception and Management of Mold' Contamination Risks

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Abstract

This study aimed to report the traditional technics used in Benin to store sorghum and millet grains and assess the knowledge level of the farmers and sellers on the problematic of mold contamination during the grain storage. Entire sorghum and millet production areas were carried out. Face-to-face interview of 1,040 farmers and sellers of both cereals were conducted. The data were collected according to an adapted set of questions

based on direct observation, group discussions, individual interviews and garret visits containing sorghum and millet. The results were analyzed using SAS software. The survey results provided by this approach showed that 93.24% of farmers were men and 100 % of sellers were women. 68.92% of farmers had over 50 years old while 64.29% of sellers had less than 35 years. Their education level was relatively low and marked by 70% of unlettered. Several storage technics are used. The most widely used is solar drying, but it has the lowest shelf life compared to the second widely used to apply the chemical pesticides to cereals product. According to them, this technic allows a long shelf life for the cereals. The most of interviewed farmers and sellers (69%) use moldy grains in animal feed while 11% used it in human consumption. 13 % of both cereals were destroyed and 7 % of them ignore that mold can have caused the sanitary risks. In view of the socio-economic importance of the cereals and their role in the nutritional needs of people it become necessary to trained the farmer and sellers in other drying and storage technics in order to prevent food-borne diseases

Key words: Sorghum, Millet, Storage, Fungi, Quality

Introduction

Sorghum (*Sorghum bicolor* L. Moench) and millet (*Pennisetum americanum* L.) are annuals grasses belonging to the family of Poaceae. There are important crops in the tropical arid and subtropical regions of Africa, Asia and central America where there are mostly used for human consumption (Kayodé, 2006; Loumerem et al., 2008). Naturally resistant to drought, sorghum and millet ensure the food and nutritional security of people (millions) in these regions. There are grown for grains used in human nutrition under different forms such as pasta, local porridge, cake and traditional beverage (Andrews and KuMar, 1992; Dicko et al., 2005; Kayodé, 2006; Adeoti et al., 2017). In Benin, sorghum and millet are key crops for agriculture and food for local populations. There rank three and four respectively for sorghum and millet after rice and maize at country level. Sorghum is cultivated both in the northern and central parts of the country, contrarily to the millet which is solely cultivated in the only northern part. Moreover, among cereals, both species are the most produced and consumed in the north.

Unfortunately, as for most of foodstuffs, cereals are susceptible to mold contamination either in the field or during storage after harvesting. Fungi' contamination is a major problem of sorghum and millet if wet conditions prevail after flowering to grain maturity and before harvest (Bandyopadhyay et al., 2000). Mold 'contamination results from bad storage conditions after the cereal harvesting. The consequences are the loss of

harvest, and consumption of contaminated cereals by mycotoxins produced by mold. However, different storage practices are mainly related to crop types and harvest quantity. Their adoption by farmers is influenced by several factors such as financial capacity, harvest period, distance between field and village (Akpavi et al., 2007). Mold contamination was well documented mainly on maize but it remained poorly documented on sorghum and millet. In Benin, both species are produced in 6 out of twelve districts and contributed to around 50% of energy of energy needs of school-aged children (Mitchikpè, 2007). With their importance in children nutrition, the major risk is related to the consumption of highly toxic food. The present study based on a participatory research approach, aims to: (i) investigate the traditional practices used to store sorghum and millet in Benin, (ii) assess the knowledge level of farmers and sellers on the problematic of mold contamination of stocked cereal and (iii) to identify different (traditional and modern) technics used to prevent and control sorghum and millet mold contaminations. Harvest storage practices remain informal and very varied in Africa.

Material and methods

Study Area

The study was conducted in Benin, a West Africa country located between the parallel 6° 30' and 12° 30' of north latitude and meridians 1° and 30° 40' of east longitude. This study was carried out from October 2015 to January 2016 in five country 'departments (Atacora, Donga, Borgou, Alibori and Collines) known as millet and sorghum production zone. These departments were located in central and northern Benin. Among the departments, a total of seventeen (17) townships, Malanville, Bembereke, N'Dali, Kandi, Savalou, Bassila, Ouake, Djougou, Copargo, Kouande, Toucountouna, Boukoumbe, Natitingou, Materi, Banikoara, Cobly and Tanguieta, were surveyed (Figure 1). At least two villages and one market were surveyed per each district to interview farmers and sellers of millet and sorghum.

Survey and data collection

Data were collected during survey through different townships using the application of Participatory Research Appraisal tools and techniques such as direct observation, group discussions, individual interviews and garret visits containing sorghum and millet. The participatory Research Appraisal tools was based on a questionnaire according to which have been previously used in similar study Adoukonou-Sagbadja et al. (2006) and Dansi et al. (2009). Face-to-face interviews were conducted in local dialect understood by farmers and sellers with the help of interpreters from each area. Some key

questions were included in the set of questions such as method of harvest, material and storage process, type of treatment made before or during storage, moisture contamination, protection methods against moisture contamination, identification of rotten grains and risks of it consumption, endogenous knowledge about mold contamination, the criteria used to identify mold 'contamination.

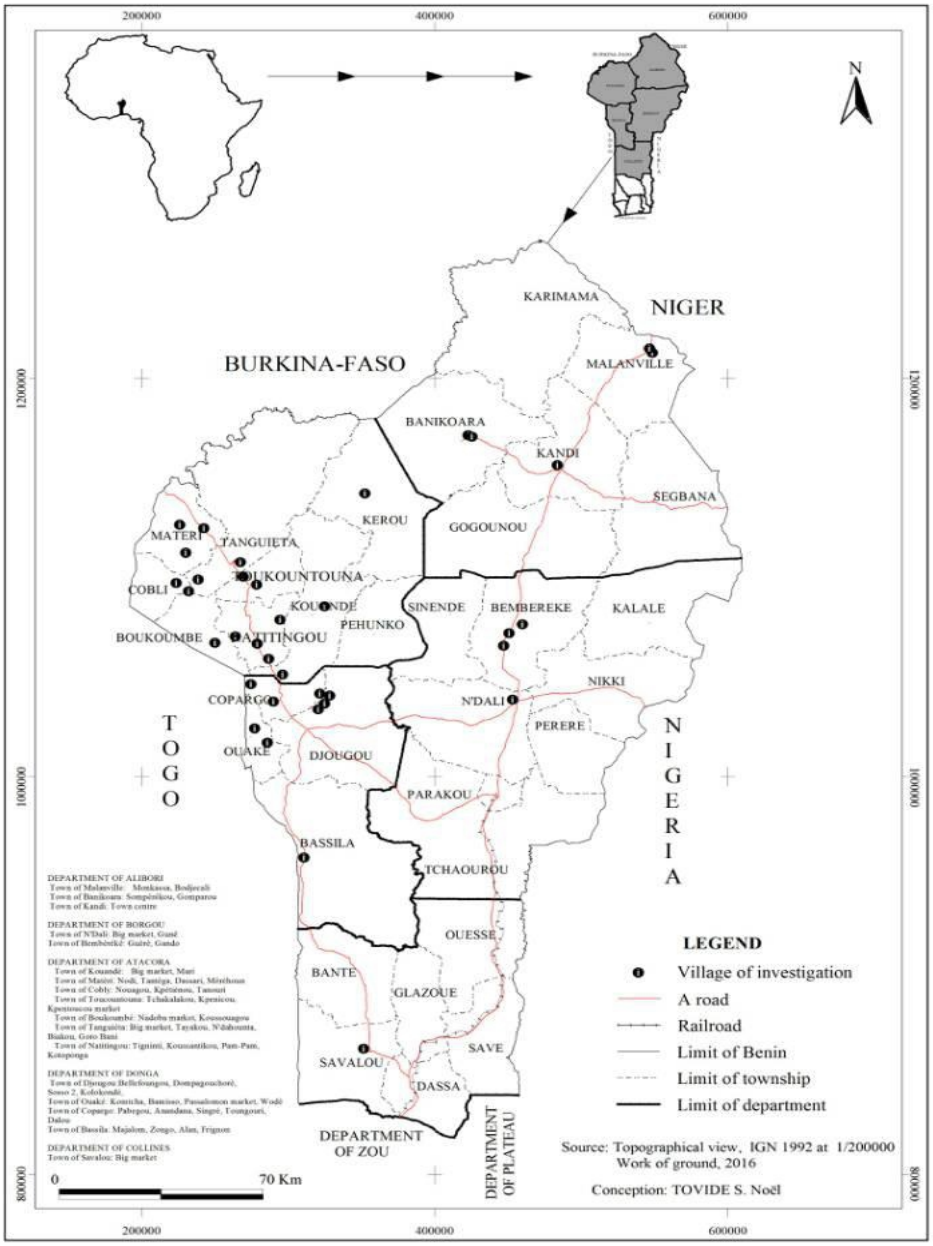

Figure 1: Geographical location of investigated districts.

Data analysis

The counting of questionnaire of investigation was carried out manually and the data were inserted on the Microsoft Excel spreadsheet. The descriptive statistical analysis was realized on these data according to different evaluated parameters in order to reach the study aims using Statistical Analysis System (SAS) software Version 8.1.

Descriptive statistics such as frequencies, means were used to analyze data collected and present the findings.

Results

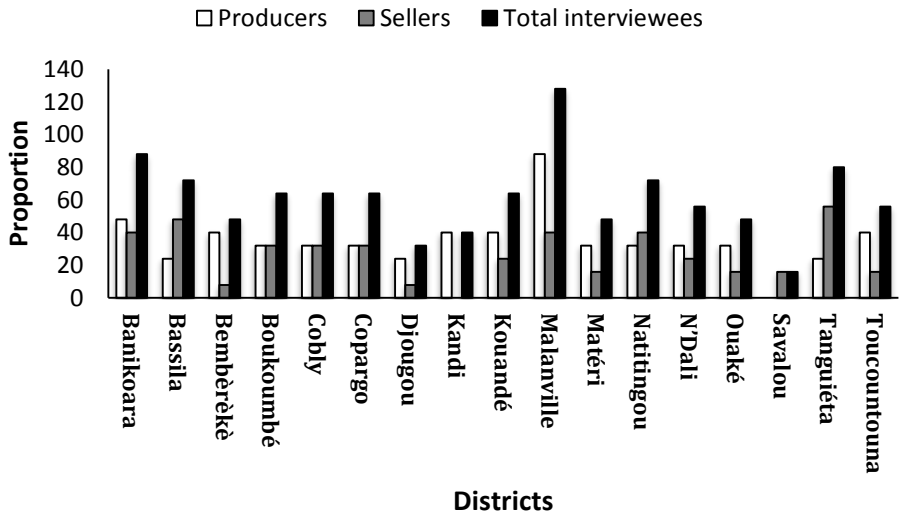

Figure 2: Distribution of interviewees according to investigated districts.

Socio-demographic characteristics of sorghum and millet farmers/sellers

The number of interviewees (farmers and sellers) varied from one district to another (Figure 2). In this study, 1,040 persons included 592 farmers and 448 sellers were interviewed. The lowest number of interviewees per district (16) was obtained in the district of Savalou (central part of Benin) while the highest number of interviewees (128) was recorded in the district of Malanville (Northern Benin).

However, for sellers the majority (39.29%) was between 26 and 35 years old while 68.92% of farmers were over 50 years old (Table 1). An assessment of respondents by gender revealed that 53.08% were male and 46.92% were female. Moreover, among sellers, only women were found to play this role in the markets.

Among the interviewees only 6.15% of all interviewees reached secondary school.

Table 1: Socio-demographic characteristics of interviewees' people.

Characteristics	Farmers		Sellers		Total	
	Number	%	Number	%	Number	%
Age						
15-25	40	6.76	112	25.00	152	14.62
26-35	104	17.57	176	39.29	280	26.92
36-50	40	6.76	56	12.50	96	9.23
>50	408	68.92	104	23.21	512	49.23
Sex						
Male	552	93.24	0.00	0.00	552	53.08
Female	40	6.76	448	100.00	488	46.92
Ethnic group						
Yom	45	7.60	35	7.81	80	7.69
Dendi	32	5.41	85	18.97	117	11.25
Otamari	168	28.38	104	23.21	272	26.15
Lokpa	88	14.86	32	7.14	120	11.54
Waama	77	13.01	35	7.82	112	10.77
Bariba	139	23.48	96	21.43	235	22.60
Other	43	7.26	61	13.62	104	10.00
Education level						
Unlettered	456	77.03	272	60.71	728	70.00
Elementary	104	17.57	144	32.14	248	23.85
Secondary	32	5.41	32	7.14	64	6.15
Other economic Activities	200	33.78	61	13.62	261	25.10

Storage' methods

Farmers and sellers surveyed adopt several sorghum and millet storage technics (Figure 3). The sorghum panicles and millet ears are dried and directly stocked in the attic by some farmers (Method 1). Some farmers stocked sorghum and millet in the grains form. This conservation method is enhanced by using biological and chemical pesticides to avoid weevil and mold' cotamination. At the time of stockage, various products are sprinkled depending on the crop size and financial capacity of farmers. Thus, grains are mixed with ash and stocked in jute bags, polyethylene bags or in attics (Method 2). These organs can also be mixed with leaves or stem bark of trees like *Azadirachta indica*, *Khaya senegalensis*, etc. and stocked in baskets or attic (Method 3). Farmers and sellers who treat sorghum and millet grains with chemical plant protection products also stocked them in jute bags, polyethylene bags that are often stocked in living room or attics (Method 4). The dose of chemical products varies according to each interviewees and the crop size). The chemical plant protection products mostly used is the 'Sofagrain' available in local markets. Finaly some farmers practice the drying by fire under attic. They stored the grains directly in the attic after ginning (Method 5).

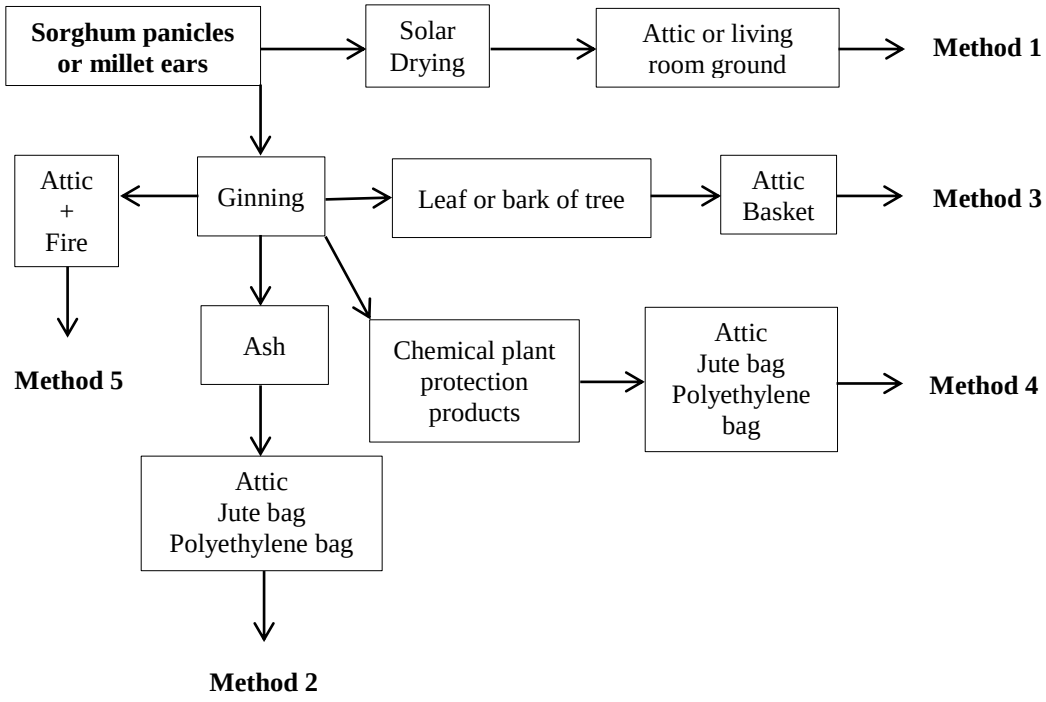

Figure 3: Diagram chart of storage technics used for sorghum and millet in Benin.

Table 2 shows the frequency of use of each storage method used by farmers and their average shelf life. The use rates ranges from 4.62% to 33.08% depending on storage methods. Solar drying (Method 1) appeared to be the most widely used method, but it does not allow long-term storage of cereals. Indeed, the conservation with chemical plant protection products (Method 4) is the most effective with a shelf life of up to 6 months.

Table 2: Use rates and performance of different storage methods.

Methods	Use rate (%)	Average shelf life of grains (month)
[1] Solar drying method	33.08	3.69 ±0.751
[2] Ash method	21.54	4.33 ±0.471
[3] Biological pesticides method	12.31	4.6 ±0.707
[4] Chemical pesticides method	28.45	6.08 ±0.837
[5] Fire drying method	4.62	5.33 ±0.471

[1], Method 1; [2], Method 2; [3], Method 3; [4], Method 4; [5], Method 5

Figure 4 shows the distribution of different technologies according to the investigated districts. The solar drying is most used in districts of Atacora, Donga and Collines. It is also widely used in Alibori district. The storage method using chemical crop conservation products is also used everywhere, except in Collines district. The ash storage method is used in all investigated districts. This remark is due to the simplicity of its use.

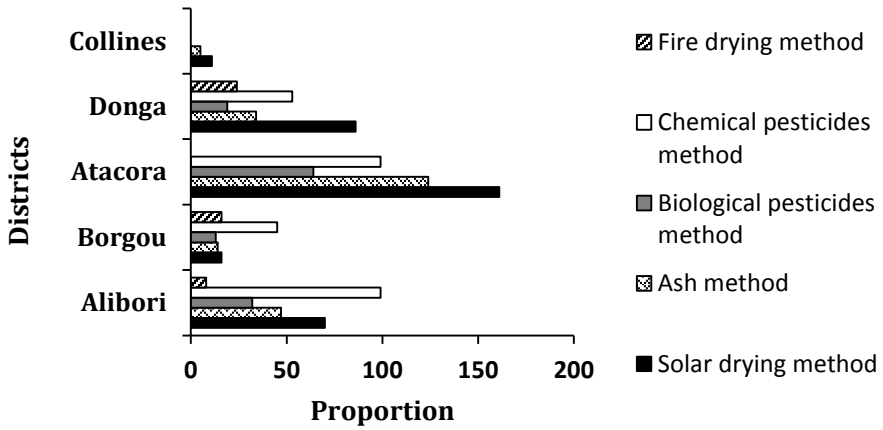

Figure 4: Distribution of storage methods used for sorghum and millet within districts.

Endogenous knowledge and farmer' perception related to fungi and mycotoxins contamination

As it has been mentioned, most of farmers and sellers are illiterate. However, they are able to appreciate modifications appeared on cereals during storage period through direct observation. The main criteria used are change in grain color and humidity. Despite that they cannot explain this change in the color, farmers are convinced of a phenomenon of grain' alteration. However, 7% are aware of danger and proceed to the destruction of contaminated stock by using fire, and 13% throw them on garbage dumps (figure 5). On the contrary, 11% and 69% of interviewees use these moldy grains respectively for human's consumption and animals feed. For these category of farmers, there is no risk to consume contaminated grains. According to the farmer, the time of appearance depends on the conservation method used.

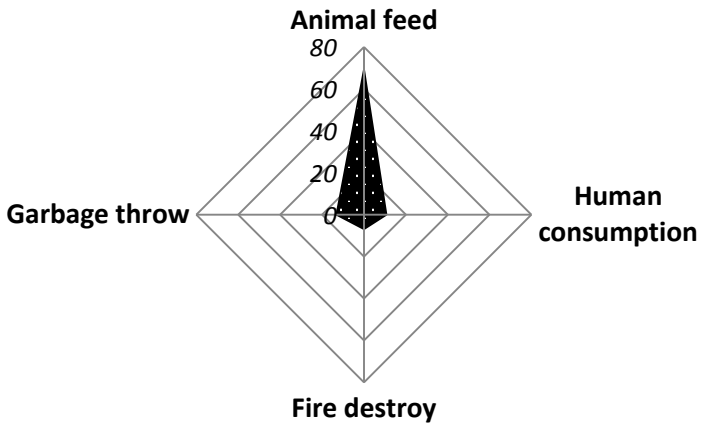

Figure 5: Different uses (%) of Sorghum and millet moldy grains.

Discussion

In West Africa, the most consumed local cereals are maize (*Zea mays* L.), rice (*Oryza sativa* L.), millet and sorghum. The byproducts of these cereals constitute the most important foods of these populations diet (Nout et al., 2003). Sorghum and millet occupy more than 90% of cereals area planted in Sub-Sahelian Africa (Akintayo and Sedgo, 2001). However, mold contamination resulted from moisture is the most recorded in cereal during storage. Indeed, farmers have few knowledge about this contamination and some of them refer to change in grain color for sorghum and millet. Similar observations were reported in previous studies in west Africa (Sibiri and Kaboré 2014). For the production, it has been reported for most of the crops species that men are more involved than women, the same result was confirmed by our study. This could be related to the low accessibility of women to land (Sohinto and Aïna, 2010). Missihoun et al. (2012) also reported that sorghum production requires enough physical investment. This remark could explain the low level of women involvement in sorghum production.

We also noticed variability between the interviewee's ages. In fact, 68.92% of farmers had over 50 years old, while 64.29% of sellers had less than 35 years old. The sellers' population is young, in contrast to that of the farmers, who mostly include family's fathers, for whom women and children realize the rural labor. Our results are contrary to those of Missihoun et al. (2012). These authors found that these cereals were grown by young farmers and explained their low yields.

According to ethnic groups encountered during this study, Otamari and Bariba ethnic groups were majority (48.75%). The other ethnic groups encountered were Lokpa (11.54%), Dendi (11.25%), Waama (10.77%), Yom (7.69%) and other ethnic groups (10%) corresponding to all minority ethnic groups encountered in the study area. This result is justified by the fact that this crops were mainly cultivated in the northern part of the country where these ethnic groups are widely represented. The low education level of interviewees probaly influenced the knowledge of farmer. Indeed, similar results were reported on maize conservation by Ba et al. (2016) who showed that only 1.27% of interviewees had a primary school level and 27% of interviewees reached secondary school and had likely to know the mycotoxins.

Concerning storage methods different technics were used and varied from one region to another and also depending on the quantity of harvest. The percentage of 33% of interviewee who used sun-dry method and store them in attics or on living home grounds is probably due to the long term storage duration before contamination. Indeed, this method allows them to conserve sorghum and millet grains for about three months and half. This

result is not in agreement with those of Abdou and al. (2013) obtained in Aguie district (Niger) who reported the same observation method for only about 5% of interviewees.

In the second method widely used, cereal grains were mixed with ash, leaves or stem barks of some trees before storage in bags. This method was based on the antimicrobial and insecticide actions of these mixtures on the mold and insects. The use of this traditional method by farmers could be related to household income or to a non-accessibility to chemical products. This result is in accordance with those reported by Hinnou and Aloukoutou (2011) for cereal storage in Benin. In contrary to the previous methods, fire drying method is only used by 4% of farmers, which indicated that the method is slightly used among farmers' population. Indeed, the method is widely used by small producers and cannot be applied for large amount of crop harvest.

Most of storage methods identified in our study are used singularly by interviewees. However, some methods are used together. Thus, some farmers-sellers mix ash with chemical crop protection products before treating cereals, in order to help to reduce the effect of chemical products. The storage method using chemical pesticides is the most effective with a shelf life up to 6 months after harvest. Akpavi et al. (2007) showed that the majority of farmers (50%) prefer to use cotton plant protection products for other cultures despite their effects on human health and the environment. Nevertheless, the method mostly preferred by farmers or sellers still remain the solar drying method. For this method, harvest is regularly removed from storage site and sun-dried during conservation time. Indeed, Ba et al. (2016) reported a shelf life of 3 to 7 months for maize storage in Benin according to this method.

Conclusion

Finally, in this study, five different methods were used for sorghum and millet storage by farmers and sellers in Benin. They are solar drying method, ash method, biological pesticides method, chemical pesticides method and fire drying method. The most widely used method is solar drying, but it has the lowest shelf life contrary to second widely used method (chemical pesticides method) which allows a long shelf life. It should also be noticed that the majority of interviewees use moldy grains in animal feed while the others use in human consumption, throw to the garbage or destroy them without knowing the associated mycotoxinogenic risks. This study made a state-of-art about endogenous farmers' perception concerning soghum and millet mold contamination and the use of contaminated crop. From our results, it appears that it is important to make sensitive right side

out of farmers and sellers to avoid consumption of mycotoxins produced in grains by mold during storage.

References:

1. Abdou, K.K.H., Kadri, A., Zakari, M.O. and Moussa, B.A. 2013. Connaissances paysannes sur la conservation du sorgho et du mil dans le département d'Aguié au Niger. *Journal des Sciences de l'Environnement*, 2 (1) : 10-18.
2. Adéoti, K., Kouhoundé, S.H.S., Noumavo, P.A., Baba-Moussa F. and Toukourou, F. 2017. Nutritional value and physicochemical composition of pearl millet (*Pennisetum Glaucum*) produced in Benin. *Journal of Microbiology, Biotechnology and Food Sciences,* 7 (1) 92-96.
3. Akintayo, I. and Sedgo, J. 2001. Towards sustainable sorghum production, utilization, and commercialization in West and Central Africa. In: Akintayo I. et Sedgo J., eds. Proceedings of a technical workshop of the West and Central Africa Sorghum *Research Network*, WASRN/ICRISAT, Lomé. pp. 162.
4. Akpavi, S., Banoin, M., Batawila, K., Vodouhe, R. et Akpagana K. 2007. Stratégies paysannes de conservation de quelques ressources phytogénétiques dans le Moyen-Mono au Togo. *Agronomie Africaine* 19(3): 337-349.
5. Andrews, D.J. and KuMar, K.A. 1992. Pearl millet for food, feed and forage. *Advances in Agronomy*, 48: 89-139.
6. Ba, R., Monteiro, N.M.F., Hounguè, U., Donou Hounsodé, M.T., Gbaguidi, F. and Baba-Moussa, L. 2016. Perception des producteurs et impact des facteurs socio-économiques sur la connaissance des mycotoxines du maïs en stockage au Bénin. *Int. J. Biol. Chem. Sci.* 10(1): 155-166.
7. Bandyopadhyay, R., Butler, D.R., Chandrashekar, A., Reddy, K.R. and Navi, S.S. 2000. Biology, Epidemiology and Management of Sorghum Grain Mold in Technical and Institutional options for Sorghum grain mold management: Proceedings of an international consultation, ICRISAT, Patancheru, India.
8. Clement, J.C. 1985. Les Mils Penicillaires de l'Afrique de l'Ouest Prospections et Collectes. *International Board for Plant Genetic Resources*, 236p.
9. CTA – Gret – Réseau TPA, 2000. Dossier d'information pour les PME d'Afrique sur la transformation agroalimentaire : Etat de la filière céréales au Bénin, 12p.
10. Dicko, M.H., Gruppen, H., Traoré, A.S., Voragen, A.G.J. and Berkel, W.J.H. 2005. Sorghum grain as human food in africa: relevance of

content of starch and amylase activities. *African Journal of Biotechnology*, 5: 384-395.
11. FAOSTAT, 2013, http://faostat3.fao.org/home/index_fr.html.
12. Friis-Hansen, E. and Sthapit, B. 1999. Overview, local PGR management and participatory crop improvement. In E. Friis-Hansen and B. Sthapit (Eds.). Participatory approaches to the conservation and use of plant genetic resources, Rome, IPGRI, 84 - 89.
13. Guèye, T.M., Seck, D., Wathelet, J.P. et Lognay, G. 2012. Typologie des systèmes de stockage et de conservation du maïs dans l'est et le sud du Sénégal. *Biotechnol. Agron. Soc. Environ*., 16(1) : 48-58.
14. Hinnou, C.L. et Aloukoutou, M.A. 2011. Stockage et conservation du maïs au Bénin : Techniques efficaces et stratégies d'adoption. Rapport d'étude, 56p.
15. Kayodé, A.P.P. 2006. Diversity, users' perception and food processing of sorghum: Implications for dietary iron and zinc supply. PhD Thesis, Wageningen University, Wageningen, p. 152.
16. Kayodé, A.P.P., Adégbidi, A, Linnemann, A.R., Nout, M.J.R., Hounhouigan, D.J. 2005. Quality of farmer's varieties of sorghum and derived foods as perceived by consumers in Benin. *Ecol. Food Nutr*., 44: 271-294.
17. Loumerem, M., Van Damme, P., Reheul, D., Behaeghe, T. 2008. Collection and evaluation of pearl millet (*Pennisetum glaucum*) germplasm from the arid regions of Tunisia. *Genetic Resources and Crop Evolution*, Volume 55, Issue 7, pp 1017–1028.
18. MAEP/DSA/DESE, 2016. Evolution de la production agricole, Annuaire statistique.
19. Missihoun, A.A., Agbangla, C., Adoukonou-Sagbadja, H., Ahanhanzo, C. et Vodouhe, R. 2012. Gestion traditionnelle et statut des ressources génétiques du sorgho (*Sorghum bicolor L. Moench*) au Nord-Ouest du Bénin. *Int. J. Biol. Chem. Sci*. 6(3): 1003-1018.
20. Mitchikpè, E.C. 2007. Towards a food-based approach to improve iron and zinc status of rural Beninese children: enhancing mineral bioavailability from sorghum-based food. Ph.D. thesis, Wageningen university, Wageningen, The Nertherlands, p.151.
21. Noumavo, P. A., Agbodjato, N. A., Baba-Moussa, F., Adjanohoun, A., Baba-Moussa, L. 2016. Plant Growth Promoting Rhizobacteria (PGPR): Beneficial Effects for Healthy and Sustainable Agriculture. *African Journal of Biotechnology*, 15: 1452-15397.
22. Nout, R., Hounhouigan, J.D. et van Boekel, T. 2003. Les Aliments : Transformation, Conservation et Qualité. Backhuys Publishers, Leiden, The Netherlands. Co-publication with ''Le Centre Technique

de Coopération Agricole et Rurale'' (CTA), Wageninhen, The Netherlands, 279p.

23. Sibiri, J.O. et Kaboré, W.T. 2014. Etude prospective sur les pertes post récoltes en Afrique de l'ouest : cas de quelques pays côtiers et du sahel. *Institut du sahel.* Rapport définitif, 44p.
24. Sohinto, D. et Aïna, M. 2010. Analyse économique et financière de cinq chaînes de valeurs ajoutées (CVA) de la filière maïs au Bénin. Rapport provisoire d'étude, 76p.